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MOBILE TEST FIXTURE SYSTEM FOR USE IN A THERMAL VACUUM FACILITY

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ABSTRACT

CBI constructed a turnkey thermal vacuum facility for Rockwell International. A key component of this facility is a mobile test fixture system which allows production line type testing of Navstar satellites. Five major subsystems are integrated into the mobile test fixture concept which minimizes turn around time between tests. All spacecraft intrumentation, wiring and computer aided checkout is performed outside of the chamber while other satellites are under thermal vacuum test within the chamber. The system is currently in use performing as expected.

INTRODUCTION

Rockwell International was awarded a contract to provide 28 Navstar satellites in the final phase of the Navstar program. The delivery schedule is such that one large thermal vacuum facility is required with a very high degree of utilization. One of the key components of the facility, to minimize spacecraft turn around time, is the mobile test fixture and transporter system as specified by Rockwell and designed and constructed by CBI. This paper describes a system which integrates five major subsystems including the transporters, multiplexers, a thermal shrouded test fixture, a thermal isolation system and an internal utility distribution system into a mobile test fixture system. See Fig. 1 and Fig. 2.

This concept allows the spacecraft to be mounted on the test fixture outside of the chamber. Instrumentation and computer checkout of the spacecraft and its instrumentation is accomplished at this station. The spacecraft, which is still mated to the test fixture, is then moved into the chamber using an air transporter system. The spacecraft then requires the connection of only two plug-in instrumentation cables and a minimum of other utilities prior to the start of thermal vacuum testing. No vertical lifts or rehandling of the satellite are required after attachment to the test fixture in the assembly area.

TRANSPORTER

The chamber has a truncated door which eliminates a pit and other floor discontinuities thus maximizing the useable floor space around the chamber as shown in Fig. 3. The absence of a door pit or slot also eliminates the need for a pit elevator or bridge. The use of a truncated door, however, results in a nine inch step up into the chamber. This elevation change is accommodated by using a two tier piggy-backed transporter system as shown in Fig. 4. The lower transporter, which remains outside of the chamber, is nine inches high and is designed to allow the upper transporter, test fixture and spacecraft to float onto the flat 20' x 30' floor section of the shroud. Both of the transporters are provided with an air bearing movement system to minimize shock transmission to the spacecraft and to allow hand movement around the lab. The lower transporter is capable of being used as a general facility cart when the test fixture is not being moved.

MULTIPLEXERS

The second key subsystem is the utilization of commercially available multiplexers mounted in the test fixture for use during pretest outside of the chamber and during the thermal vacuum testing inside the chamber. Four Hewlett Packard model No. 3498 multiplexers are mounted within each of the two test fixtures as shown in Fig. 5. This concept was inspired by Don Glover and first used by Boude Moore at McDonnell Douglas. The multiplexers were modified by CBI and extensively tested successfully by Don Glover of Rockwell.

Disassembly of the multiplexers is required to remove non-vacuum compatible frame materials. The multiplexers also require active heating to operate in the 80 K, high vacuum environment. The multiplexers are mounted between 3/8" thick aluminum plates painted to achieve an emissivity of 0.9. Each plate is equipped with a 120 watt cartridge heater for the thermal conditioning. These heaters are designed to be powered by computer controlled, time proportioning power supplies. Rockwell technicians found that simple on-off thermostat control of the heater provides adequate temperature regulation so that the computer controlled power supplies can be used for other functions. Vacuum compatability also requires that the multiplexer cabling be supplied with teflon insulated wire.

The use of the multiplexers on the test fixtures allows Rockwell to instrument and wire the spacecraft with up to 800 data channels prior to spacecraft entry into the chamber. This means that wiring and an extensive pre-test program can be accomplished while another spacecraft is still under test within the chamber. The only instrumentation wiring that must be completed within the chamber is the connection of two plug-in cables to the test fixture multiplexers from the computer control and data acquisition system which is located outside of the chamber. The 800 channel capability of the multiplexers provides Rockwell with a 50% redundancy to enhance reliability.

Two similar multiplexers are located on fixed mounts within the vacuum chamber for transmission of all chamber instrumentation. These units are provided to minimize wiring and feedthru costs and to maximize the flexibility to alter instrumentation for any individual test that may be required. These multiplexers are also thermally conditioned to operate in the thermal vacuum environment.

Rockwell International conducted an extensive test program to ensure that the multiplexers were suitable for operation over the entire operational range of the chamber. The multiplexers were even operated throughout the corona discharge pressure range to ensure that the units would provide a continuous link with the spacecraft. The highest voltage encountered in the multiplexer was the 110 V power supply.

CBI supplied a networked computer system and software for facility control, data acquisition, data manipulation and display. This system consists of four HP 1000 series computers including two model A600 computers and two model A900 computers. The system also includes tape, hard disk memory storage, video control stations and hard copy printing and plotting capability. The computer system allows simultaneous control and data acquisition for the chamber and its related systems as well as for a spacecraft under test within the chamber and a spacecraft under pre-test or post-test checkout outside of the chamber. The computer system along with the multiplexers installed on the test fixture almost completely eliminates in-chamber hook-up and check out of the spacecraft environmental support systems.

TEST FIXTURE THERMAL SHROUDS

The third significant feature of the test fixture system is the thermal shrouds on each test fixture as shown in Fig. 6. The thermal shrouds thermally screen the spacecraft from the test fixture and are designed to thermally approximate the operational characteristics of the chamber thermal wall in the LN_2 and GN_2 modes of operation. These shroud circuits are temperature controlled by the internal utilities system.

The use of thermal shrouds on the test fixture eliminates any radiation from warm test fixture structural elements thus minimizing the time required for the spacecraft to reach thermal equilibrium. The thermal shrouds on the test fixture also eliminate heat loads from the multiplexers and their heaters.

INTERNAL UTILITIES SYSTEM

The fourth subsystem of the mobile test fixture system is an internal utilities system. This system provides liquid and gaseous nitrogen supply and return connections and electrical feedthrus for fast and convenient hook-up. These utility connections are located in the area below the flat thermal wall floor. This area below the floor is an ideal location because connections can be made to fluid manifolds and electrical feedthrus without interference from a shroud which is installed very close to the chamber shell. Normal access to the area below the shroud floor is a hatch through the floor.

Two fluid supply manifolds are provided within the chamber to thermally condition all auxiliary shroud circuits such as the test fixture shrouds, a decontamination plate or any thermal targets which may be required. One manifold provides four taps for LN_2 only. The other manifold provides 26 taps for either LN_2 or heated GN_2. The temperature of auxiliary shroud circuits is computer controlled using a thermocouple mounted on the auxiliary panel which operates a solenoid valve located in a discharge manifold vessel. The discharge manifold vessel is installed within the chamber. The system is shown schematically in Fig. 7.

The discharge manifold vessel is installed within the vacuum chamber for a number of reasons. The first is that the vessel does not require thermal insulation if it is located within the chamber due to the insulating effect of the vacuum. The second reason is that only one six inch bayonet type chamber penetration is required for GN_2 discharge instead of twenty four ½" diameter penetrations that would be required for individual circuits. This vessel is shown in Fig. 8.

Twenty four individual circuits penetrate the valve box through twelve Conflat type ports. The circuits then discharge through Magnatrol solenoid valves which are located within the discharge manifold vessel. GN_2 is then vented out of the chamber and building through the six inch diameter vent line. Any liquid nitrogen carryover is allowed to vaporize within the vessel. Each individual circuit is connected using Cajon VCR fittings. Individual circuits are capped when not in use. The Cajon fittings proved to be very reliable in high vacuum, cryogenic service. The Conflat flanges are provided to allow access for maintenance to each pair of Magnatrol valves.

The solenoid valves used in the discharge manifold vessel must operate in a cryogenic condition and may even be submerged in LN_2 in the event of a thermal control failure. CBI, therefore, tested three brands of solenoid valves. The tests were conducted at CBI's Plainfield, Illinois research facility and were conducted to determine which solenoid valve could operate properly if submerged in LN_2. It was found that only the Magnetrol valve would perform properly under these conditions.

All instrumentation and electrical feedthrus for the chamber are located in three 48" ϕ pods installed on the bottom of the chamber. Each of the pods is provided with six 12" ϕ instrumentation ports. These ports have hinged quick opening blind flanges which can be adapted for almost any feedthru requirement. The design includes a full opening (48" ϕ) bottom hatch which allows the technician to work on the outside or inside connections at chest level. See Fig. 9.

Computer controlled power supplies were provided as part of the internal utilities system. The power supplies were prewired into the chamber using feedthrus located in the 48" ϕ instrumentation pods and prewired into the computer system with process variable feedback returning to the computer through the multiplexers. The power supplies consist of 20 autoranging D.C. units which are capable of 0-10 AMPS, 0-60 volts and up to 200 watts; 40 A.C. time proportioning units capable of 110 V and 40 AMPS; as well as 18 low voltage D.C. units. PID and RAMP control is available for each of the units with simple fill in the blanks type programming.

THERMAL CONTROL OF SPACECRAFT SUPPORT RING

The fifth subsystem consists of active thermal control for the spacecraft support ring of the test fixture. See Fig. 10. The temperature of the support ring is controlled to minimize conductive heat transfer between the spacecraft and support ring thus simulating a free flying spacecraft.

Thermal control of the support ring is provided by multiple 50 watt cartridge heaters attached to the support ring. The cartridge heaters are computer controlled using a differential temperature type thermocouple circuit which is attached to the support ring and the spacecraft. Any temperature difference between the support ring and the spacecraft activates the heaters. Active cooling of the support ring is not required because of the test cycle parameters and the thermal conditions within the spacecraft.

CONCLUSION

In the past, the majority of thermal vacuum facilities have been constructed with little regard to test turn around time. However, close consideration to the requirements of production line type testing as exhibited by Rockwell International has allowed CBI to design a facility with many innovative features, expressly designed for rapid turn around.

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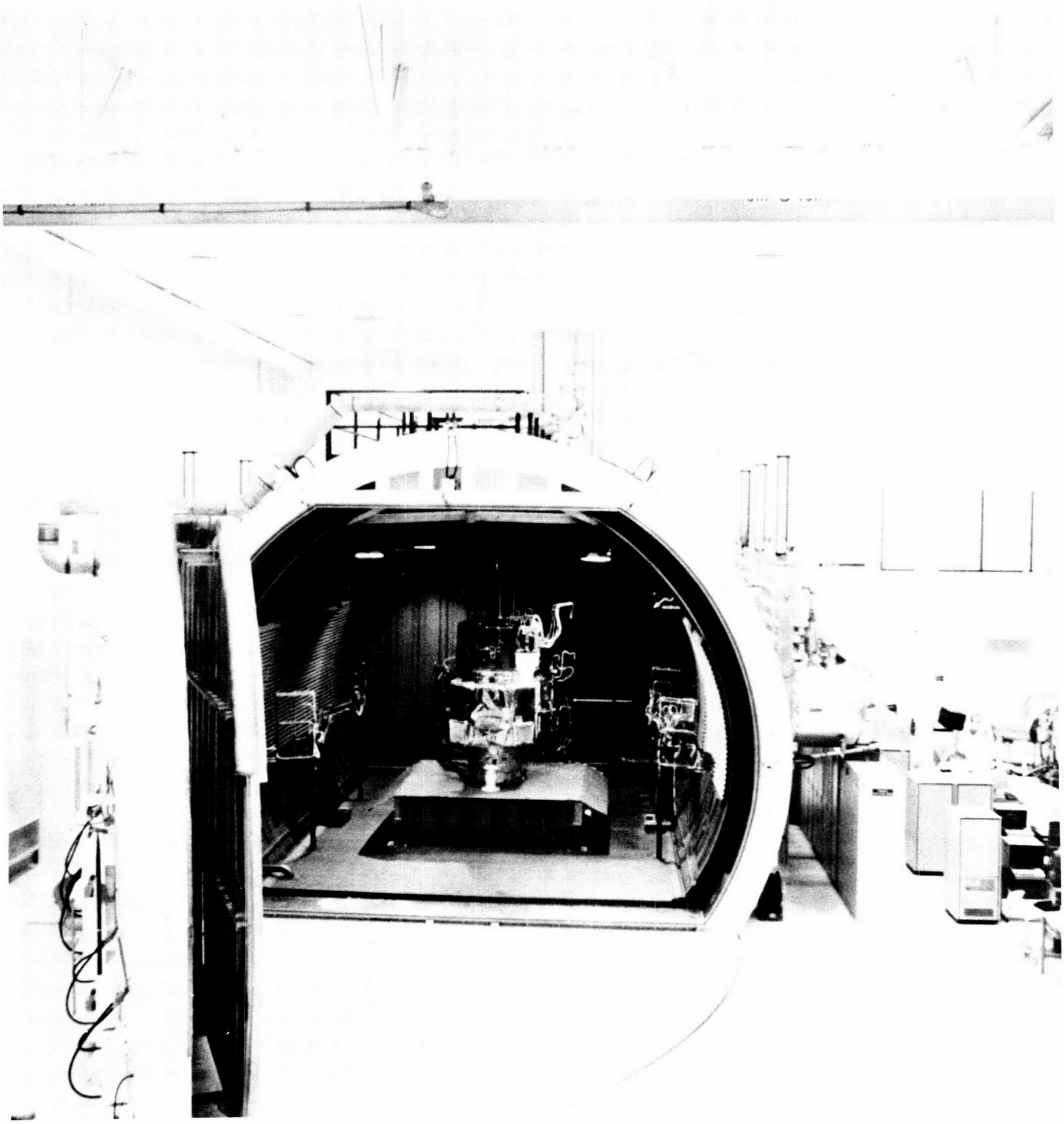

Figure 1. Facility overview

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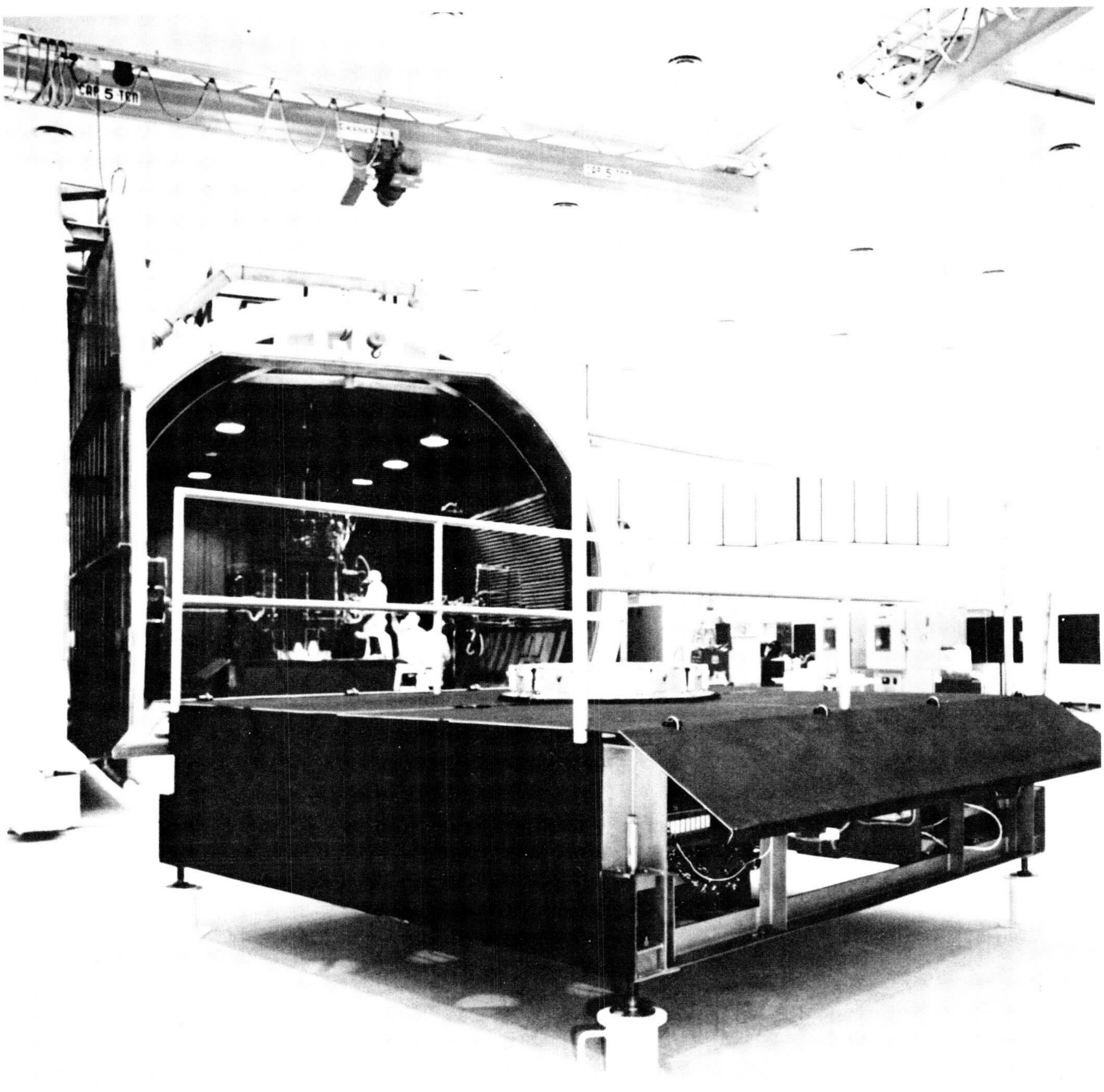

Figure 2. Test fixture

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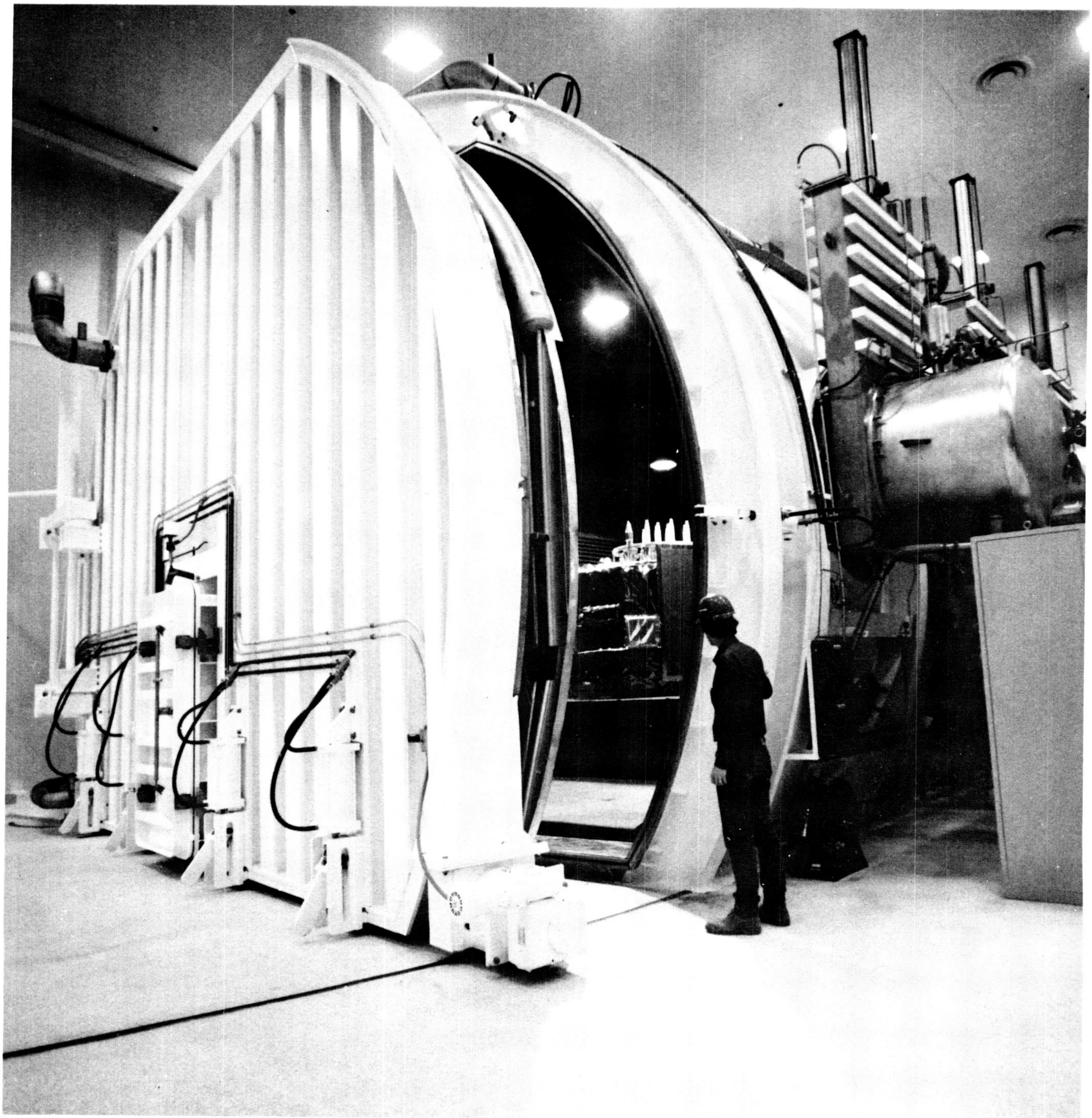

Figure 3. Truncated chamber door

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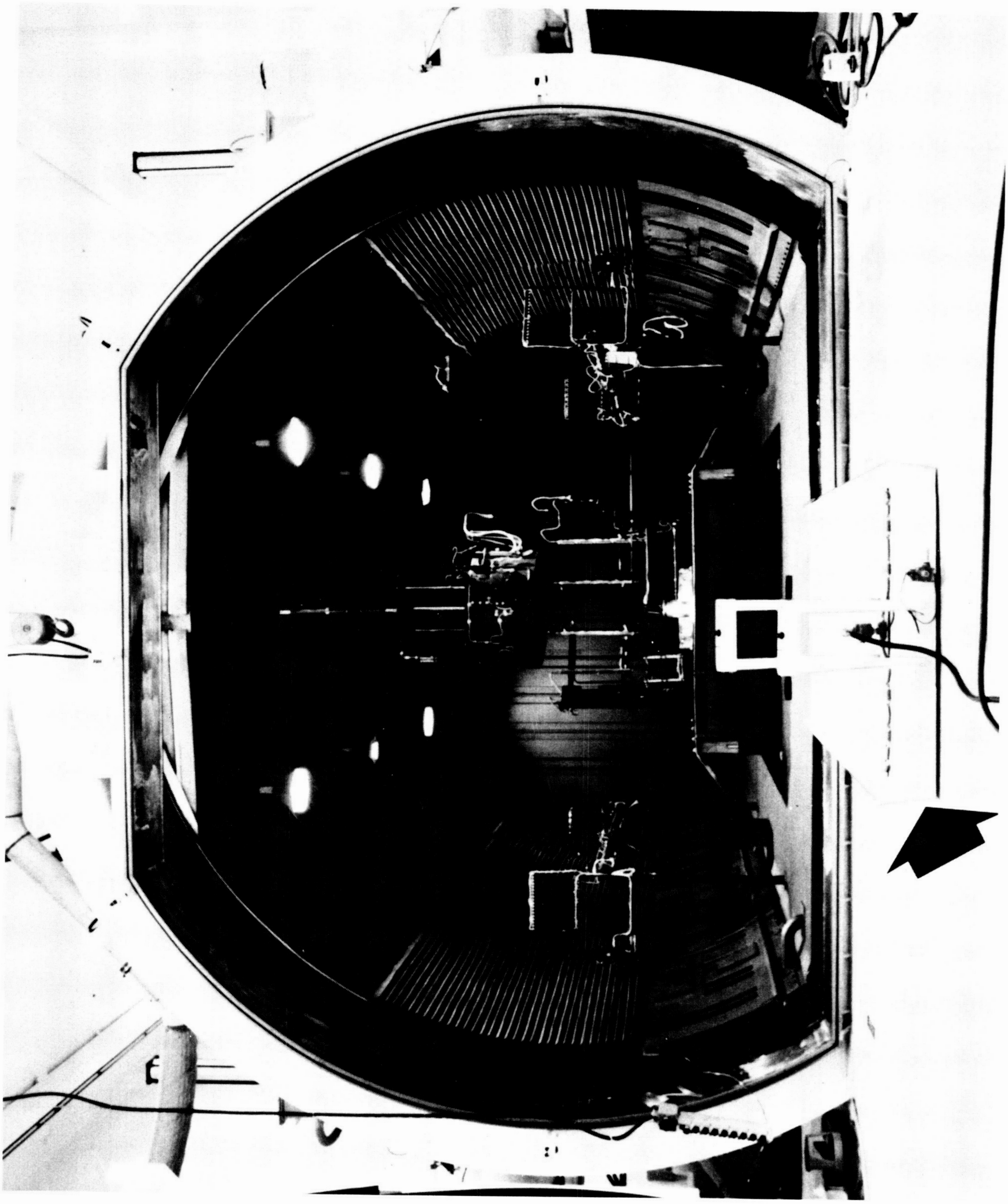

Figure 4. Transporter

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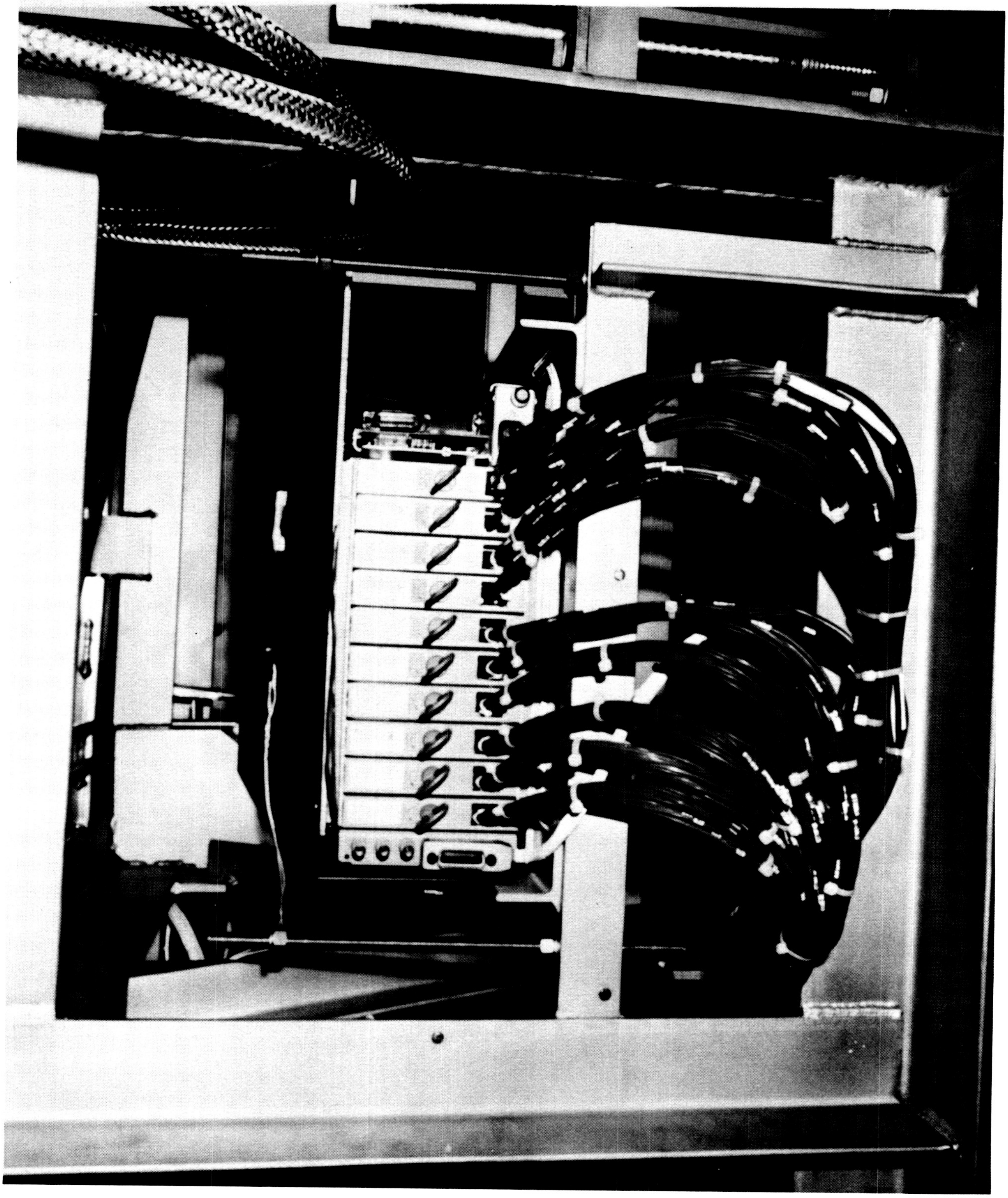

Figure 5. Test fixture multiplexers

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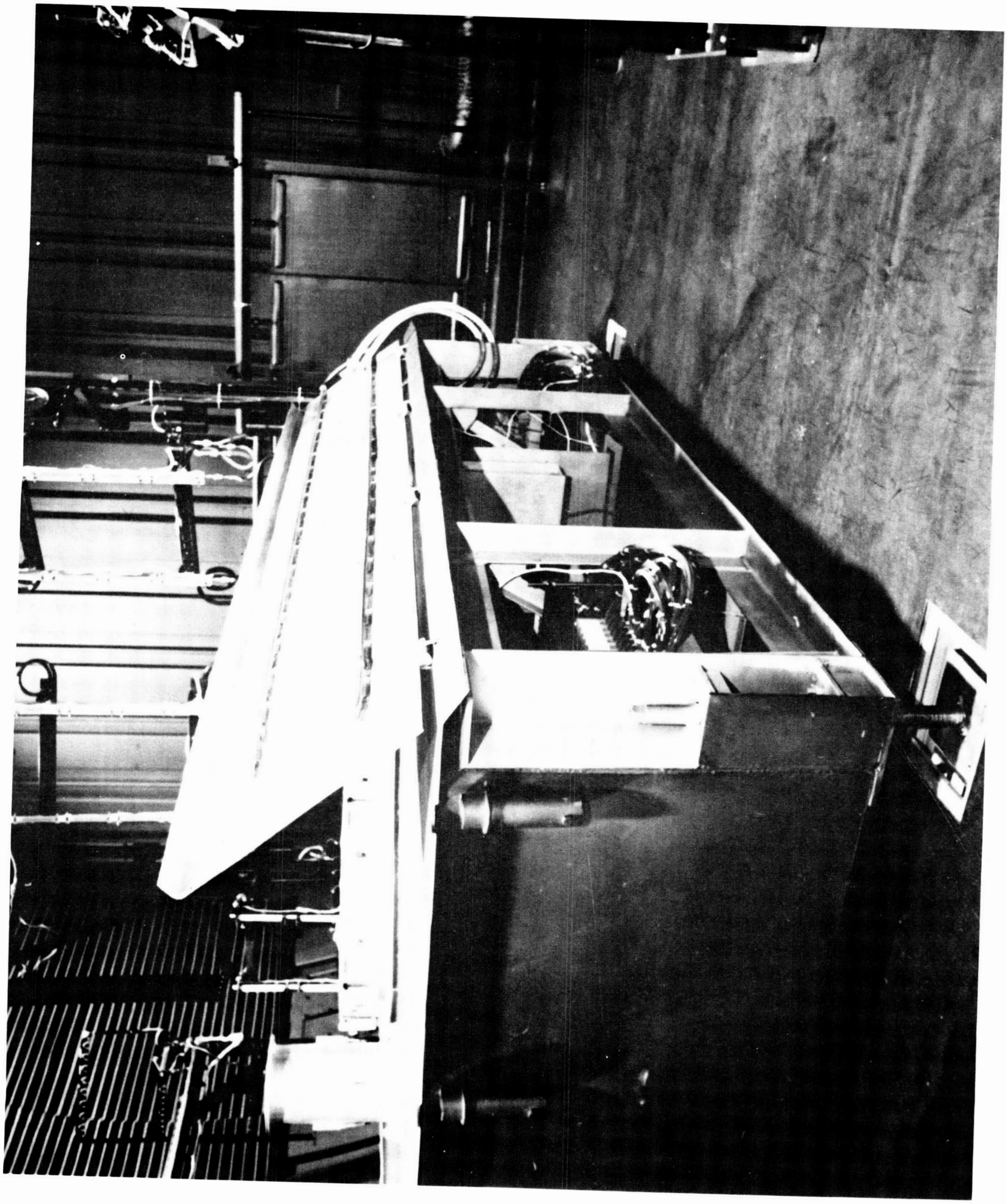

Figure 6. Test fixture thermal shroud panels

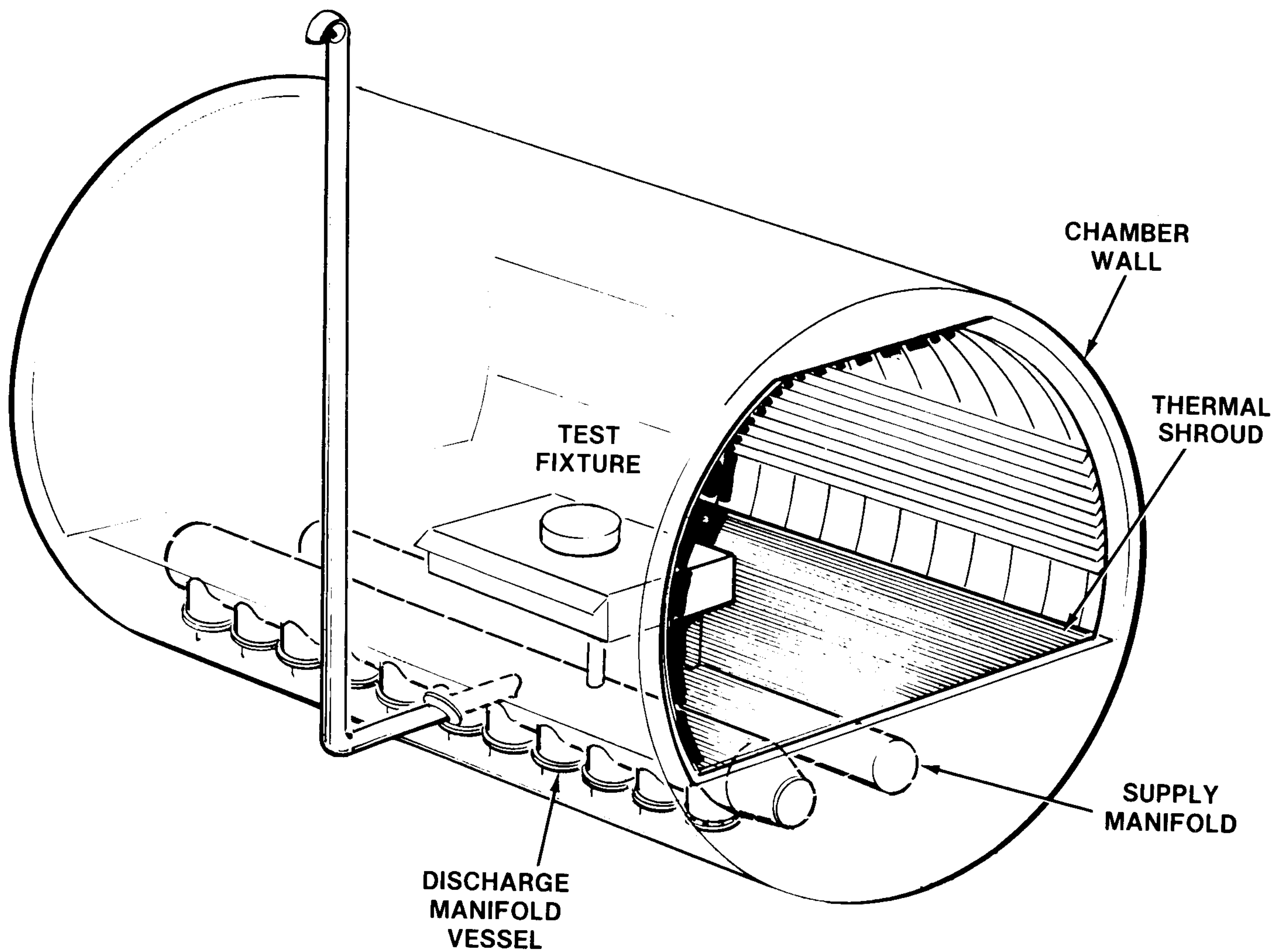

Figure 7. Internal utilities schematic

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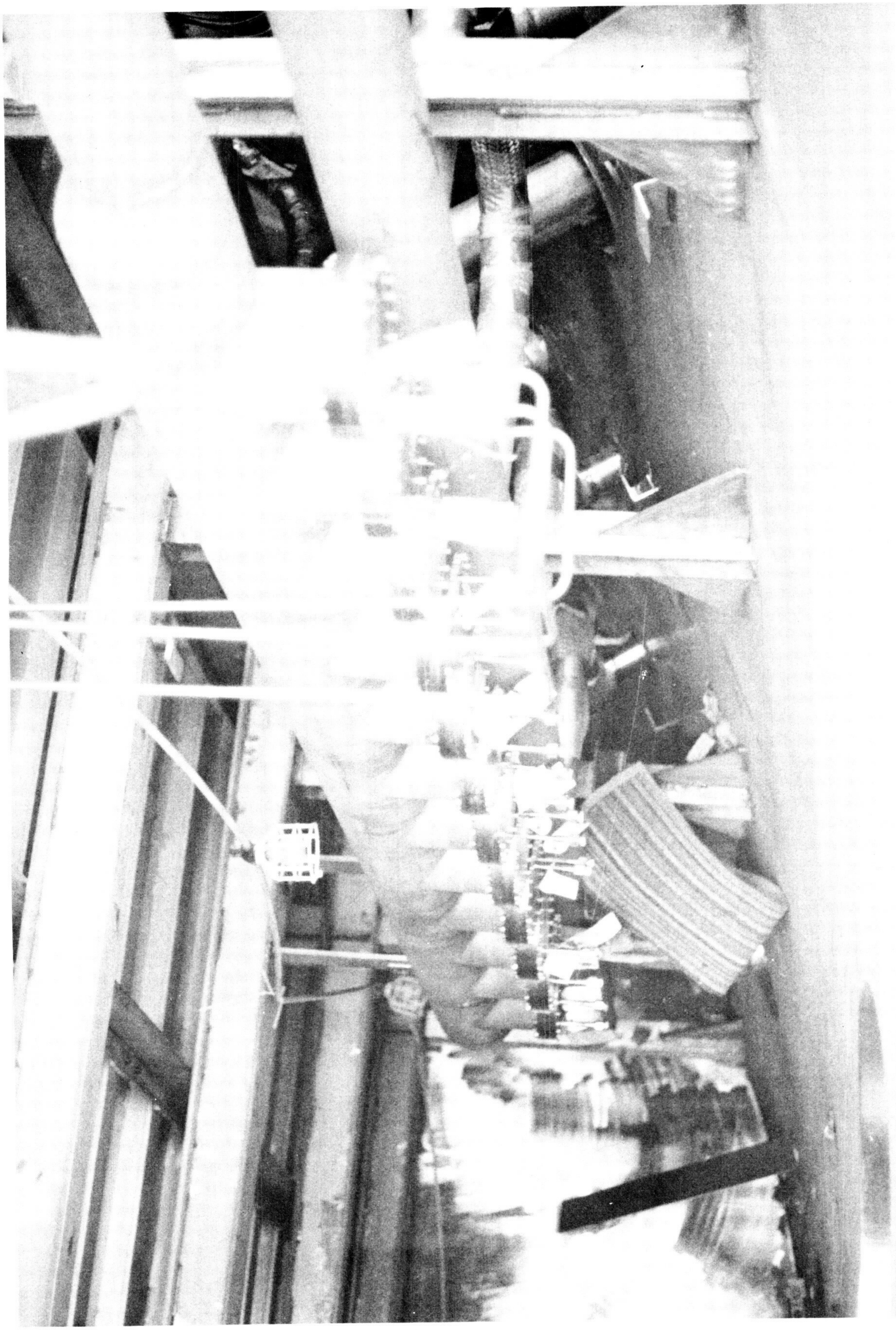

Figure 8. Discharge manifold vessel

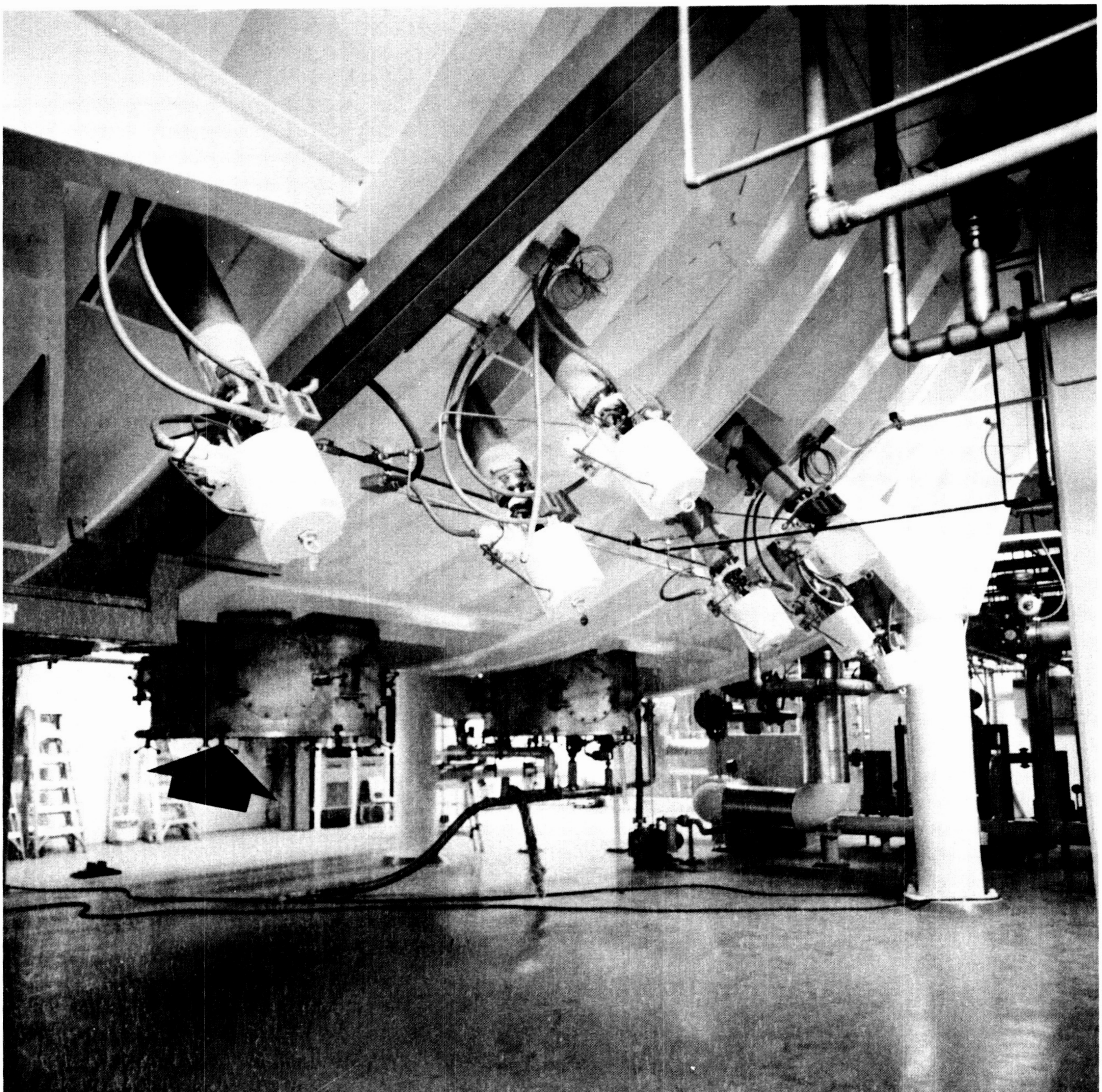

Figure 9. Instrumentation pods

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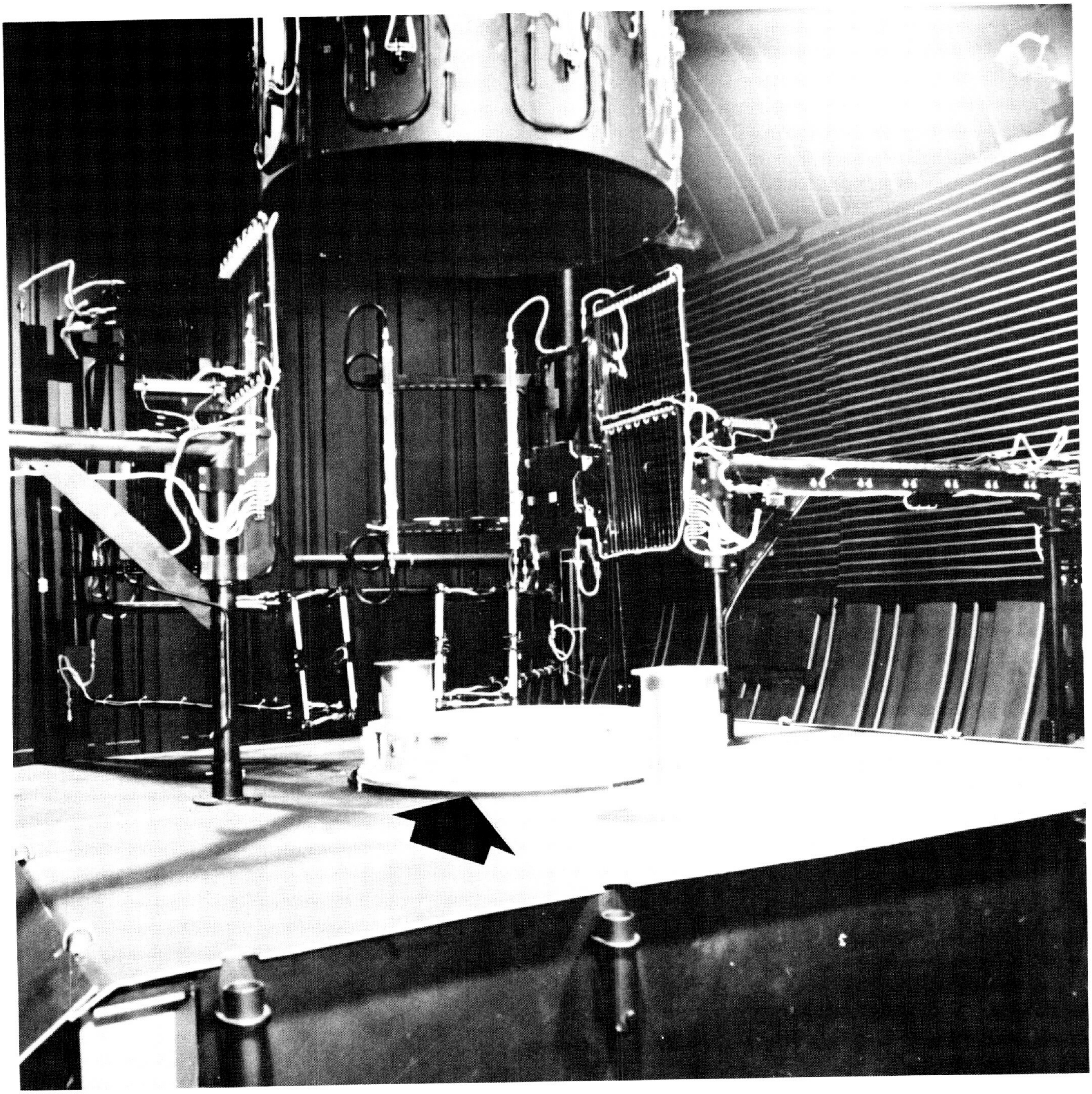

Figure 10. Space craft support ring